NUMMULITIC ROCKS OF THE ISLANDS OF AMAKUSA (KYUSHU, JAPAN)

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BY

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With 5 Plates and 2 Text-Figures

In 1922, Mr. TAKUMI NAGAO, of our Institute of Geology and Palæontology, unexpectedly discovered two new localities of nummulitic rocks[1] on Amakusa-Shimo-shima[2] and Shishi-jima.[3] Though the former island is one of the Islands of Amakusa, which belong to the province of Higo,[4] and the latter is included in the province of Satsuma,[5] yet, geotectonically speaking, this division is not admissible, and both islands constitute, together with Amakusa-Kami-shima[6] and a number of adjacent smaller islets, the Islands of Amakusa and are quite independent of the opposite land of Kyûshû.[7]

According to the recent stratigraphical study of Mr. NAGAO, the Islands of Amakusa are essentially constituted of the Cretaceous and Older Tertiary formations in a gentle syncline and lying upon gneisses along the eastern wing and upon crystalline schists of the Sambagawa along the western wing. There are also several igneous rocks intruding in and covering the sedimentaries. The Cretaceous and the Tertiary deposits are divided by him into the following groups:

1. The Goshonoura[8] Group. Prevailing rock of this group is bluish-gray fine-grained sandstone easily turned yellowish by weathering. Mr. S. YEHARA lately described from this sandstone several

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[1] T. NAGAO: "Nummuite-bearing Beds in the Amakusa Islands (Japanese)," *Jour. Geol. Soc., Tôkyô*, Vol. XXX, No. 353, 1923, pp. 51–55. Also T. NAGAO in the same Journal, Vol. XXX, No. 357, 1923, p. 248.

Other important papers on the geology and palæontology of the islands of later dates are: S. YEHARA: "Isumi Sandstone of Kyûshû (Japanese)," *Jour. Geol. Soc., Tôkyô*, Vol. XXVIII, No. 337, 1921, pp. 389–394. T. NAGAO: "Geology of the Islands of Amakusa (Japanese)," *Jour. Geol. Soc., Tôkyô*, Vol. XXIX, 1922, No. 341, pp. 41–56; No. 342, pp. 90–100. S. YEHARA: "Cretaceous Trigoniæ from Amakusa Islands, Prov. Higo, Kyûshû, Japan," *Jour. Geol. Soc., Tôkyô*, Vol. XXX, 1923, pp. 1–12. S. YEHARA: "Cretaceous Trigoniæ from South-western Japan," *Jap. Jour. Geol. & Geogr.*, Vol. II, 1923, No. 3, pp. 59–84.

[2] 天草下嶋.
[3] 獅子嶋.
[4] 肥後.
[5] 薩摩.
[6] 天草上嶋.
[7] 九州.
[8] 御所之浦.

species of *Trigonia;*[1] and a species of *Callista;*[2] it is almost equivalent to the *Acanthoceras* or *Trigonia longiloba* Zone[3] of the Ishikari[4] coalfield in Hokkaidô.[5] Cenomanian.

2. The Himenoura[6] Group. Black shale, intercalating median to coarse-grained grayish sandstone and conglomerate beds in several horizons near the base and top; it is contemporaneous with the Upper Ammonites Beds of the Ishikari coalfield in Hokkaido, containing, according to Mr. NAGAO,

Mesopachydiscus cf. *haradai* JIMBO
Gaudryceras tenuiliratum YABE — Most common
Hamites haradanus YOK.
Peroniceras amakusense YABE
Mortoniceras sp.
Nautilus sp.
Pectunculus sp.
Trigonia subovalis JIMBO var. *minor* YABE and NAGAO
Inoceramus cf. *regularis* D'ORB.
,, *schmidti* MICHAEL var.

Lower Senonian.

3. The Miroku[7] Group. This overlies the Himenoura in apparent, but not real, conformity; the lithological characters show an abrupt change in passing from one to the other. This group consists of, in ascending order:

a. The Akasaki[8] Beds. Shales and sandstones in alternation, all usually thin-bedded, and sometimes with a thin conglomerate at the base; characterized by the vivid colours of the rocks, either reddish brown or bluish.

b. The Shiratake[9] Sandstone. A thick homogenous complex of white arcose sandstone, with intercalation of thin conglomerate layers; an *Orthaulax* bed[10] and one or more thin coal seams are

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[1] S. YEHARA: "Cretaceous Trigoniæ from South-western Japan." In this paper, he describes
Trigonia hokkaidoana YEHARA
,, *pocilliformis* YOK.
,, *dilapsa* YEHARA nov. sp.
,, *ogawai* YEHARA nov. sp.
,, *sakakurai* YEHARA nov. sp.
,, *sakakurai* var.
,, *subovalis* JIMBO.
,, *kikuchiana* YOK.

His *T. pocilliformis* represents a form different from *T. pocilliformis* YOK., and Mr. NAGAO proposed a new name *T. pustulosa* for it; his *T. subovalis* is *T. subovalis* JIMBO var. *minor* YABE and NAGAO (the description will be given in a forthcoming paper, YABE and NAGAO: "New or Little Known Cretaceous Fossils from North Saghalin (Lamellibranchiata and Gastropoda)," to be published in *Jap. Jour. Geol., & Geogr.*, 1925). *T. hokkaidoana* is based on too imperfect specimens and there is some doubt about the specific identification.

[2] S. YEHARA: "On the Izumi Sandstone Group in the Ônogawa Basin (Prov. Bungo) and the same group in Uwajima (Prov. Iyo)," *Jap. Jour. Geol. & Geogr.*, Vol. III, No. 1, p. 38, 1924. His *Callista* cf. *plana* (SOWERBY) from the Goshonoura Group may possibly be identical with *C. pseudoplana* YABE and NAGAO var. *alata* YABE and NAGAO from Hokkaidô and North Saghalin, described in their paper on the Cretaceous fossils from North Saghalin, cited above.

[3] H. YABE: "Cretaceous Cephalopoda from the Hokkaidô," Pt. I, *Jour. Coll. Sci. Tôkyô.* Vol. XVIII, 2, 1903, p. 5. H. YABE: "Zur Stratigraphie und Paläontologie der oberen Kreide von Hokkaidô und Sachalin," *Zeitsch. d. deutsch. Geol. Gesell.*, Vol. XXI, 1909, p. 407.

[4] 石狩.
[5] 北海道.
[6] 姫之浦.
[7] 彌叡.
[8] 赤崎.
[9] 白岳.

[10] T. NAGAO: "Occurrence of *Orthaulax* in the Palæogene of Japan," *Jap. Jour. Geol. & Geogr*, Vol. III, No. 1, 1924, pp. 16.
There is another *Orthaulax* zone occupying a little higher horizon in the Takashima and Miike coal-fields, in Kyûshû.

intercalated near the base of this complex at Akase,[1] Uto[2] Peninsula, and Mirokudake[3] on Amakusa-Kami-shima. The *Orthaulax* bed contains, according to Mr. NAGAO, two characteristic fossils, among others, namely

Orthaulax japonicus NAGAO

and a *Glauconia*-like gastropoda. The Shiratake Sandstone exposed along the coast of Taguizaki on Shishi-jima contains abundant *Nummulites*; more in detail, we see there

Nummulitic sandstone, partly conglomeratic	50 ft.
Black shale	150 ,,
Nummulitic sandstone	30 ,,
Sandstone and coaly shale	20–30 ,,
Red shales and sandstones of the Akasaki Beds.	

The nummulitic sandstone overlying the black shale and that underlying it contain *Nummulites amakusensis-subamakusensis* nov. sp. in abundance, while *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN was obtained only from the middle part of the upper sandstone. Molluscan shells also are often found in the sandstone, and *Turritella* sp. is most common. An *Orthaulax* bed has not yet been found exposed at this place, though the coaly shale beds lying upon the Akasaki red beds evidently point without doubt to this horizon.

The Miroku Group is replaced on Amakusa-Shimo-shima by Fukami[4] Sandstone, a marine complex with the basal conglomerate containing numerous blocks of shales derived from the older, Himenoura Group; the sandstone contains, sparsely *Venericardia nipponica* YOK. and intercalates a shell layer *ca.* 100 ft. below its top. The shell layer contains the same *Glauconia*-like gastropoda as the *Orthaulax* bed cited above, and represents the same horizon.

4. The Hondo[5] Group. The Shiratake Sandstone of the Miroku Group and the Fukami Sandstone is succeeded upward by the Hondo Group, which is subdivided into two:

a. The Kyôragi[6] Shale. Black shale and fine, brownish-gray sandstone in alternation, the latter often containing many fragmental plant remains. Shale predominates in the middle part. A few small limestone lenses, hardly 3 ft. thick, are found intercalated in the lower part of the Kyôragi Shale at Hongô,[7] Miyanokawachi-mura,[8] on the east coast of Amakusa-Shimo-shima; the limestone contains

Nummulites amakusensis-subamakusensis nov. sp.	Abundant
Nummulites spp.	Abundant
Orthophragmina (*Discocyclina*) aff. *pratti* MICHELIN	Abundant
Orthophragmina (*Asterodiscus*) sp.	Common

The lower part of the Kyôragi Shale developed on the east coast of Amakusa-Shimo-shima, and a part of the Shiratake Sandstone developed on Shishi-jima intercalate the same *Nummulites* bed, and must be contemporaneous, though in different facies of sediments. The nummulitic limestone intercalated in the black shale is a more off-shore deposit; this is evident not only from the lithological nature of the sediments, but also from the rarity of *Orthophragmina* in the one and its abundance in the other.

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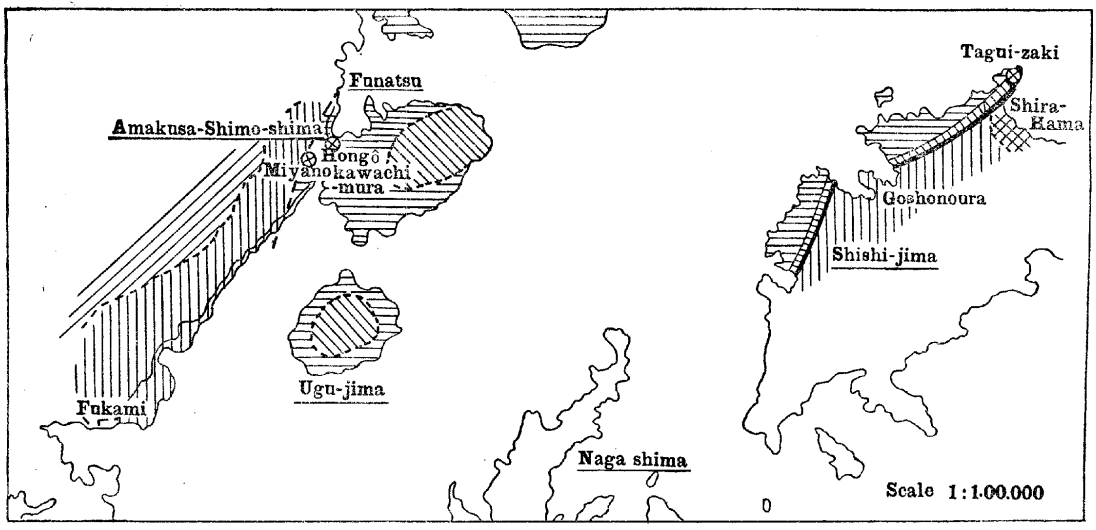
[1] 赤瀬.
[2] 宇土.
[3] 彌勒嶽.
[4] 深海.
[5] 本渡.
[6] 教良木.
[7] 本郷.
[8] 宮野河内.

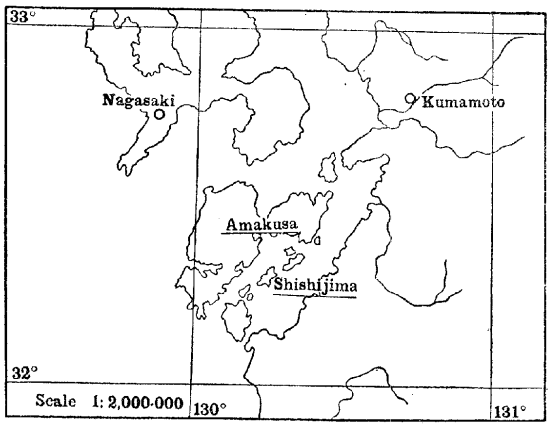
b. The Toishi[1] Beds. Usually white, sometimes gray, fine to median-grained sandstone; massive except in the uppermost part, where it is thin-bedded and intercalates several workable coal seams, with many silicified woods and plant impressions.

5. The Sakasegawa[2] Group. A marine formation, overlying the preceding one in apparent conformity; it consists of two parts, namely:

a. Itchôda[3] Sandstone. Mostly fine to median-grained sandstone, dark bluish in colour, owing to the glauconite grains it contains. Fossil mollusca are common at places; they are

Crassatella fusca YOK.
Venericardia nipponica YOK.
Lima amakusense YOK.
Pholadomya margaritacea (SOW.)





Goshonoura Group
Himenoura Group
Fukami Sandstone
Akasaki Beds
Shiratake Sandstone
Kyôragi Shale
Toishi Beds
Localities of Nummulites

[1] 砥石.
[2] 坂瀬川.
[3] 一町田.

b. The Sakasegawa Shale. Black to gray shale, intercalating some layers of sandstone. It frequently contains a large species of *Lima*.

Nummulitic rocks known from Japan, previous to the discovery of them on the Islands of Amakusa, are enumerated by one of us (YABE) in an article "Tertiary Rocks with Higher Foraminifera from Japan"[1]; there are two principal occurrences of nummulitic rocks, namely:

1. Nummulitic tuff of Haha-jima[2] in the Ogasawara[3] Group; it is full of *Nummulites* which Mr. S. TÔKUNAGA once assigned to *Nummulites javanus* VERBEEK and *Nummulites baguelensis* VERBEEK. A part of the microspheric form resembles *Nummulites vredenburgi* PREVER and another part *Nummulites laevigatus* LAM.; hence the tuff is believed to represent the Upper Lutetian. The other foraminifera found in association with the *Nummulites* are[4]:

   Sagenina regularis H. DOUVILLÉ
   „ *expansa* YABE
   Placopsilina cenomana D'ORB.
   Lituotuba sp.
   Orthophragmina colcanapi R. DOUVILLÉ(?)
   Alveolina cf. *javana* VERB.
   „ spp. (2).
   Eorupertia boninensis YABE and HANZAWA[5]

2. Nummulitic limestone of Kukunô-sha, Akô-chô,[6] Taiwan[7]; it is full of the test of *Orthophragmina* belonging to two species and a small *Nummulites* belonging to *Radiatae*.

The geological age of the nummulitic tuff of Haha-jima is Middle Eocene (Lutetian), while that of the *Orthophragmina* and *Nummulites* limestone of Kukunô-sha, Formosa, is either Middle Eocene or a little younger. Mr. NAGAO'S discovery of the nummulitic rocks of the Lower Lutetian or Ypresian stage in the Islands of Amakusa is of considerable importance.

The Islands of Amakusa are situated at about 32° 17′ N. L., and this point marks the northernmost locality of *Nummulites* along the Asiatic border of the Pacific, so far as we know at present, although the foraminifera are distributed far to the north (52° N. L.) in Europe. For comparison, the northern extension of the area of distribution of the genera *Orbitolina, Orthophragmina, Lepidocyclina, Miogypsina, Cycloclypeus*, and *Operculina* in the western Pacific is shown in the annexed table.

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[1] *Jour. Geol. Soc., Tôkyô*, Vol. XXVII, 1920, pp. 4, 19–21. This is written in Japanese and an abstract is in H. YABE: "Recent Stratigraphical and Palæontological Studies of the Japanese Tertiary," *Proc. Pan-Pacific Sci. Conf., Hawaii*, Vol. III, 1921, pp. 794–795.

[2] 母島.

[3] 小笠原.

[4] H. YABE: "Notes on Some Eocene Foraminifera,"
1. "Four Arenaceous Foraminifera from the Eocene of Haha-jima (Hillsborough Is.), Ogasawara (Bonin) Group," *Sci. Rep. Tôhoku Imp. Univ. Second Series (Geology)*, Vol. V, No. 4.

[5] H. HABE and S. HANZAWA: "*Uhligina*, A New Type of Foraminifera Found in the Eocene of Japan and West Galicia," *Jap. Jour. Geol. & Geogr.*, Vol. I, No. 2, 1922.
In this paper, we applied the new generic name "*Uhligina*" for two peculiar species of foraminifera, one from West Galicia and another from the nummulitic-tuff of Oki-mura, Haha-jima; but the designation having been preoccupied by Dr. R. J. SCHUBERT for a particular type of *Uvigerina* (Die Miocäne Foraminiferenfauna von Karwin, Oesterr. Schlesien. *Lotos* 19 (57), 1899), the term of "*Eorupertia*" is here proposed as its substitution.

[6] 阿緱廳.

[7] 臺灣.

Genera	Geol. Age	Northernmost Loc.	N. L.
Orbitolina[1]	Lower Cretaceous	Near Shimo-Furano[2] along the Sorachi-[3] gawa, prov. of Ishikari, Hokkaidô	43° 18′
Orthophragmina	Eocene	Islands of Amakusa	32° 17′
Lepidocyclina[4]	Miocene	Nakaosaka,[5] prov. of Kôzuke.[6]	36° 15′
Miogypsina	Miocene	Nishi-Kurosawa,[7] Oga[8] Peninsula	39° 58′
Cycloclypeus[9]	Pliocene?	Okinoerabu-jima,[10] Riukiu[11] Islands	27° 25′
Operculina[12]	Miocene	West of Tanosawa,[13] Nishi-Tsugaru-gori,[14] prov. of Mutsu[15]	40° 45′

Nummulites amakusensis (Form B) sp. nov.

subamakusensis (Form A) sp. nov.

Pl. XVIII (I), Fig. 5; Pl. XIX (II), Figs. 1, 3, 9; Pl. XX (III), Figs. 1–5; Pl. XXI (IV), Figs. 5–7.

Microspheric form: little over 10 mm. in diameter; lenticular in younger stage of growth, but later flat discoidal, with rounded periphery. Surface smooth, with numerous delicate striæ, which are subparallel, flexuous like S, converging toward, and rarely coalescing near, the center of the disc; the striæ show sometimes a tendency to make meander especially near the center of the disc. Neither granules nor granule-like thickenings of septa visible on the surface.

Volutions rather apart, very irregular; septa numerous, but not much crowded, thin and uniform in thickness throughout their whole length, curving abruptly backward near the periphery, elsewhere slightly curved or almost straight and extending nearly to the radial direction. Chambers rather spacious, usually higher than broad. There are about 35 septa in a volution, 6 mm. in diameter.

Megalospheric form: at most 5.5 mm. in diameter; flat discoidal in full-grown stage, with rounded periphery. Striæ on the surface of the disc simpler than those of the micospheric form. Nucleoconch consisting of two subequal chambers, and measuring 0.4 mm. in greatest diameter. Otherwise almost like the microspheric form.

One of the specimens, here figured, shows the following number of septa:

1st volution	1. mm. in diameter	11 septa
2nd ,,	1.4 mm. ,, ,,	22 ,,
3rd ,,	1.9 mm. ,, ,,	22 ,,
4th ,,	3.2 mm. ,, ,,	27 ,,
5th ,,	4.5 mm. ,, ,,	29 ,,

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[1] H. Yabe: "Cret. Cephalopoda," p. 5. H. Yabe: "Zur Stratigraphie," p. 407.
[2] 下富良野.
[3] 空知川.
[4] Based on new material collected by Mr. Sh. Toyama from Nishi-Kurosawa.
[5] 中小坂.
[6] 上野.
[7] 西黒澤.
[8] 男鹿.
[9] H. Yabe and S. Hanzawa: "Geological Problem on the Raised Coral-Reefs of the Riukiu Islands and Taiwan; a Consideration based on the Fossil Foraminifera Faunas contained in the Raised Coral-Reef Formation and in the Youngest Deposit underlying It," *Sci. Rep., Tôhoku Imp. Univ.*, Ser. II (Geology), Vol. VII, No. 2, 1924.
[10] 沖之永良部嶋.
[11] 琉球.
[12] H. Yabe: "Notes on *Operculina* Rocks from Japan, with Remarks on *Nummulites cumingii* Carpenter," *Ibid.*, Vol. IV, No. 3, 1918.
[13] 田之澤.
[14] 西津輕郡.
[15] 陸奥.

The present form resembles *Nummulites planulatus-subplanulatus*[1] on one side and *Nummulites irregularis-subirregularis*[2] on the other, and is intermediate between them in certain respects. Thus it has in common with *Nummulites planulatus-subplanulatus*, straight and radial septa, spacious chambers and absolutely non-granulated surface, and with *Nummulites irregularis-subirregularis*, flat discoidal form and irregular and rather widely separated volutions. *Nummulits bolcensis-spileccensis*[3] is another allied form; but is characterized by its septal prolongation being thickened at places and thus appearing granulated.

Localities and Geological Horizons: Hongô, Miyanokawachi-mura, on Amakusa-Shimo-shima (near the base of the Kyôragi Shale), and Tagui-zaki on Shishi-jima (the Shiratake Sandstone).

Nummulites spp.

Pl. XVIII (I), Fig. 6; Pl. XIX (II), Figs. 2, 3, 4, 7, 8; Pl. XX (III), Fig. 6; Pl. XXI (IV), Figs. 1–4; Pl. XXII (V), Figs. 1, 8, 9, 10, 11, 12

The limestone from Hongô contains, in addition, numerous smaller, thick lenticular tests of *Nummulites*, which certainly comprise several distinct species; the difficulty of isolating these specimens from the matrix for the examination of their surface-markings and for the preparation of oriented thin sections, renders their specific distinction and determination exceedingly difficult.

Among a few specimens either isolated from the matrix or at least exhibiting a part of the surface of the test exposed from it, we can distinguish the following four types:

1. Pl. XIX (II), Fig. 2. Test 4 mm. in diameter, thick lenticular, with rounded margin; surface showing *ca.* 25 simple, slightly flexuous septal sutures extending radially and provided with a cluster of narrow pillars at the central part of the disc, whose heads are not prominent on the surface of the test. It resembles *Nummulites lucasi* (Defr.) D'ARCH.[4]

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[1] *Nummulites planulatus-subplanulatus* (*elegans* auct.): literature consulted is
1853. *Nummulites planulata* D'ARCHIAC et HAIME: "Monographie des *Nummulites*," pp. 142–144, Pl. IX, figs. 5*a*, 6*a*–6*c* (B), 7*a*–7*h*, 8*a*–8*d*, 9*a*-9*b*, 10*a*–10*c* (A).
1883. *Nummulites planulata* DE LA HARPE: "*Nummulites* de Suisse," pp. 171–175, Pl. VII, figs. 1–11 (B).
1883. *Nummulites elegans* DE LA HARPE: *Op. cit.*, pp. 175–177, Pl. VII, figs. 12–23 (A).
1906. *Nummulites subplanulatus* H. DOUVILLÉ: "Evolution des *Nummulites*," *Bull. Soc. Geol. France*, ser. 4, Vol. VI, p. 16 (A).
1911. *Nummulites planulatus* BOUSSAC: "Études paléontologiques sur le Nummulitique Alpin," p. 13, Pl. I, figs. 1, 8, 9; Pl. II, figs. 23–25 (A and B).
1919. *Nummulites planulatus* H. DOUVILLÉ: "L'Éocène inférieur en Aquitaine et dans les Pyrénées," pp. 46–49, Pl. IV, figs. 1–12 (A).
1919. *Nummulites subplanulatus* H. DOUVILLÉ: *Op. cit.*, p. 49 (A).

[2] *Nummulites irregularis-subirregularis:* literature consulted is
1853. *Nummulites irregularis* D'ARCHIAC et HAIME: *Op. cit.*, pp. 138, 139, Pl. VIII, figs. 16–18, 19*a* (B).
1853. *Nummulites distans* var. *depressa* D'ARCHIAC et HAIME: *Op. cit.*, p. 93, Pl. II, fig. 4*a* (B).
1883. *Nummulites irregularis* DE LA HARPE: *Op. cit.*, pp. 154–158, Pl. IV, figs. 16–34; Pl. V, figs. 1, 2 (B).
1883. *Nummulites subirregularis* DE LA HARPE: *Op. cit.*, pp. 158, 159, Pl. V, figs. 3–14 (A).
1911. *Nummulites irregularis* BOUSSAC: *Op. cit.*, pp. 18–21, Pl. I, figs. 17, 21, 22 (A and B); text-figs. 2–4.
1919. *Nummulites irregularis* H. DOUVILLÉ: *Op. cit.*, pp. 68, 69; Pl. V, figs. 22–29; Pl. VII, figs. 1, 2 (B).

[3] *Nummulites bolcensis-spileccensis:* literature consulted is
1911. *Nummulites bolcensis* BOUSSAC: *Op. cit.*, pp. 16, 17, Pl. I, figs. 2, 3, 10, 11 (A).

[4] D'ARCHIAC et HAIME: "Monographie d. *Nummulites*," 1853, p. 124 (*partim*). J. BOUSSAC: "Études paléontologique alpin," p. 52, Pl. II, figs. 14, 15. H. DOUVILLÉ: "L'Eocène inf. en Aquitaine et dans les Pyrénées," 1919, p. 59, Pl. I, figs. 18 38.

2. Pl. XXII (V), Fig. 12. Test 6 mm. in diameter, thick lenticular, with rounded margin; surface showing *ca.* 30 simple, flexuous septal sutures extending radially; with no trace of radial pillars visible on the surface. It resembles *Nummulites guettardi* D'ARCH.[1]
3. Pl. XXII (V), Fig. 8. Test 1.5 mm. in diameter, hence being smaller than the preceding two; more convex; surface showing 19 simple septal sutures, directed conspicuously backward; no trace of the radial pillars visible on the surface.
4. Pl. XX (III), Fig. 6. Test 1.5 mm. in diameter, very convex and appearing almost biconical; septal sutures almost straight, simple, extending radially; with a central knob, but lacking any other trace of pillars visible on the surface. It resembles *Nummulites subatacicus* DOUVILLÉ.[2]

On the other hand, there are numerous sections of these smaller tests of *Nummulites* in random thin slices of the limestone; among them we can distinguish the following types:

a. Fig. 1 on Plate XXI (IV). This represents a test cut obliquely and excentrically; *ca.* 5.5 mm. in the longer diameter, hence being almost of the same size as megalospheric *Nummulites subamakusensis*. It is, however, distinguished from *Nummulites subamakusensis* by being more convex; apparently there is no trace of vertical pillars. This may possibly be identical with type 2 of the isolated specimens.

b. Fig. 4 and Fig. 9 on Plate XIX (II). The former represents a test in transverse section, slightly excentric, which is 4.25 mm. in diameter and 1.8 mm. in thickness, while the latter figure shows another specimen of a nearly equivalent size, in oblique tangential section. Both agree with type 1 of the isolated specimens in size and by showing numerous narrow pillars clustered at the center of the test.

c. Figs. 9, 10, and 11 on Plate XXII (V). The first and second figures represent two convex specimens in oblique section, which are *ca.* 4 mm. in diameter. Though much larger, these remind one of type 4 of the isolated specimens. The third figure, in horizontal excentric section, shows another example, probably of the same type. All these are characterized by having slightly flexuous simple septal sutures, which extend almost radially, and a broad pillar-like structure at the center.

Seven other sections, four transverse and three horizontal, cut through nucleoconch, are shown by Figs. 3 and 4 on Pl. XXI (IV), Figs. 3 and 7 on Pl. XIX (II), and Fig. 6 on Pl. XVIII (I). They are all megalospheric and vary from 2 to 3 mm. in diameter. Of the four transverse sections, two (Fig. 3 on Pl. XIX (II) and Fig. 3 on Pl. XXI (IV)) are distinguished from the other two (Figs. 2 and 4 on Pl. XXI (IV)) by having a larger initial locule. Of the three horizontal sections, one (Fig. 7 on Pl. XIX (II)) is provided with bilocular nucleoconch and the other two (Fig. 6 on Pl. XVIII (I)) with unilocular. Correlation of these sections with any of the preceding types, 1–4 and *a–c*, is impossible to be carried on with any reliance.

Locality: Hongô, Miyanokawachi-mura, on Amakusa-Shimo-shima.

Geological horizon: Near the base of the Kyôragi Shale.

Orthophragmina (Discocyclina) aff. **pratti** MICHELIN

Pl. XVIII (I), Figs. 4, 6; Pl. XIX (II), Figs. 1, 4; Pl. XXI (IV), Fig. 8;
Pl. XXII (V), Figs. 2, 3

Test attaining 10 mm. in diameter and 0.8 mm. in thickness; thin lenticular or almost flat, but slightly thickening toward the center. Nucleoconch large, 0.5 mm. in the greatest diameter, low;

[1] D'ARCHIAC et HAIME: "Monographie," p. 130, Pl. VII, figs. 18, 19.
[2] DOUVILLÉ: *Loc. cit.*, p. 41, Pl. III, figs. 7, 8.

composed of two locules, the second one entirely embracing the first (in a manner like those of an *Eulepidina*). Median chambers low, about 30 cycles in a 2 mm. radial distance from the center; lateral chambers twice as large as the median, on an average, thin-walled. Pillars numerous, slender, being far inferior to the lateral chambers in breadth. Surface finely pustulated; pustules (which are the heads of the pillars) evenly distributed on the whole surface of the test.

Closely allied to *Orthophragmina pratti* MICHELIN,[1] which, however, shows smaller lateral chambers and relatively broader pillars and pustules.

Localities and Geological Horizons: Hongô, Miyanokawachi-mura, on Amakusa-Shimo-shima (near the base of the Kyôragi Shale) and Tagui-zaki on Shishi-jima (the Shiratake Sandstone).

Orthopragmina (Asterodiscus) sp.

Pl. XIX (II), Fig. 1; Pl. XXI (IV), Fig. 8; Pl. XXII (V), Figs. 1, 5–7

Specific determination of *Orthophragmina* belonging to the section *Asterodiscus* by means of thin sections only and without isolated specimens for comparison is an almost hopeless task. In our thin slices of the nummulitic rocks, we find another species of *Orthophragmina*, along with the preceding one and distinguished from it by being polygonal in outline, and by being composed of smaller lateral chambers, broader pillars, and smaller megalospheric nucleoconch. In transverse sections, the disc of this species is thick lenticular, never appearing as flat as in the preceding species.

With great difficulty, we succeeded in freeing only a small fragmental specimen of this type from the matrix; this is shown by fig. 7 on Pl. XXII (V). Judging from this specimen, it must be a species of *Asterodiscus*, somewhat like *Orthophragmina stella* GÜMBEL,[2] with only slightly developed stellar prolongations and with conspicuous radial ridges.

Locality: Hongô, Miyanokawachi-mura, on Amakusa-Shimo-shima.

Geological Horizon: Near the base of the Kyôragi Shale.

CONSIDERATION OF THE GEOLOGICAL AGE OF THE FORAMINIFERA-FAUNA. The type specimens of *Nummulites planulatus-subplanulatus* are from the Sand of Cuise, near Paris, in which this species occurs together with *Alveolina oblonga* D'ORB; the Sand of Cuise is the type deposit of DOLLFUS' Cuisan Stage, which closely corresponds to the Ypresian of MUNIER-CHALMAS and LAPPARENT. The Ypresian and the next older, Sparnacian, combined, make the Londinian of E. HAUG.[3]

Nummulites planulatus-subplanulatus is also recorded from the Aquitanian Basin[4] in France, where it occurs together with *Nummulites irregularis-subirregularis, Nummulites lucasi, Nummulites atacicus-subatacicus, Nummulites globulus-guettardi* and several other species of this genus, and marks the Ypresian stage. *Orthophragmina* is also found in the same nummulitic horizon, being represented by such forms as *Orthophragmina archiaci* SCHLUMBERGER and *Orthophragmina pratti*.

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[1] *Orthophragmina pratti* MICHELIN: literature consulted is

1868. *Orbitoides (Discocyclina) papyracea* (pars) GÜMBEL: "Beiträge zur Foraminiferenfauna der nordalpinen Eocängebilde," *Abh. d. k. bayer. Akad. d. Wiss.*, p. 112, Pl. III, figs. 4, 5, 8, 11, 12, 14, 22–27.

1902 *Orthophragmina pratti* (pars) SCHLUMBERGER: "Troisieme note sur les *Orbitoides*": *Bull. Soc. Géol. France*, ser. 4, Vol. III, p. 274, Pl. VIII, figs. 1, 3, 10; Pl. IX, fig. 17 (non Pl. VIII, figs. 2, 8, 9); text-fig. A.

1912. *Orthophragmina pratti* PREVER: "La Fauna a Nummuliti e ad Orbitoidi der terreni Terziarii dell'alta valle dell' Aniene," *Mem. Carta Geol. d'Italia*, Vol. V, p. 122, Pl. I, fig. 1; Pl. III, figs. 1, 2.

[2] CH. SCHLUMBERGER: "Quatrième Note sur les Orbitoides," *Bull. Soc. Géol. France*, ser. 4, Vol. IV, 1904, p. 132, Pl. VI, figs. 47–50, 52–56.

[3] E. HAUG: "Traité de Géologie," II, 3, p. 1418.

[4] H. DOUVILLÉ: "L'Éocène inférieur en Aquitaine et dans les Pyrénées," 1919.

Nummulites bolcensis spileccensis is believed usually to be an ancestral form of *Nummulites irregularis-subirregularis*, and is known from the Ypresian of Italy. *Nummulites irregularis-subirregularis*, though recorded from the Ypresian of the Aquitanian Basin by DOUVILLÉ, has, however, its principal distribution in the Lutetian and especially in its lower division—Lower Lutetian.

Nummulites planulatus-subplanulatus and *Nummulites irregularis-subirregularis* are also known from the contemporaneous deposits of N. Africa[1] and S. India; in S. India,[2] the former species occurs in the upper Ranikot, and the latter in the Laki and Lower Khirthar. It is noteworthy that *Nummulites irregularis* of the Laki is not the typical one, but a variety somewhat intermediate between the species and *Nummulites planulatus*. Further, the Laki contains several species of *Orthophragmina*.

All these faunal relations indicate that the nummulitic rocks of Amakusa-Shimo-shima and Shishi-jima are either Ypresian or Lower Lutetian in age, and not younger.

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[1] Dareste de la Chavanne: "La Région de Guelma étude speciale des Terrains Tertiaires," 1910, p. 292, Pl. II, figs. 17, 18; p. 300, Pl. II, figs. 16, 17*a-d*.

[2] E. VREDENBURG: "*Nummulites douvillei*, an underscribed species from Kachh, with Remarks on the Zonal Distribution of Indian *Nummulites*," *Rec. Geol. Surv. India*, Vol. XXXIV, pt. 2, 1906. E. VREDENBURG: "Note on the Distribution of the Genera *Orthophragmina* and *Lepidocyclina* in the Nummulite Series of the Indian Empire," *id.*, Vol. XXXV, pt. 1, 1907. H. DOUVILLÉ: "Les Foraminifères de l'île de Nias," *Samml. Geol. Reichsmuseums Leiden*, I, Vol. VIII, pt. 5, 1912, pp. 258, 259.

PLATE XVIII (I)

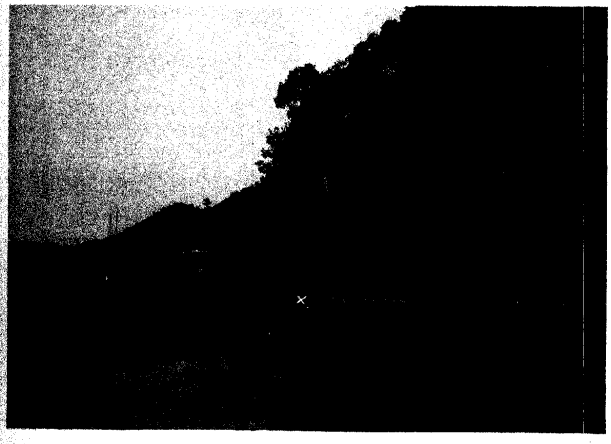
Figs. 1, 2. An exposure of nummulitic limestone intercalated in the Kyôragi shale near its base, at Hongô, Miyanokawachi-mura, Amakusa-Shimo-shima; a distant (1) and a near view(2) from S. to W.

Fig. 3. Taguizaki, Shishi-jima; an exposure of nummulitic sandstone along the seashore.

Fig. 4. *Orthophragmina* (*Discocyclyna*) aff. *pratti* MICHELIN; surface of a specimen from the nummulitic sandstone of Taguizaki, Shishi-jima. × 10.

Fig. 5. *Nummulites amakusensis* YABE and HANZAWA; surface of a specimen from the nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Fig. 6. A thin section of the nummulitic limestone from Hongô, Miyanokawachi-mura, Amakusa-Shimo-shima; showing *Nummulites* sp. and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN. × 20.



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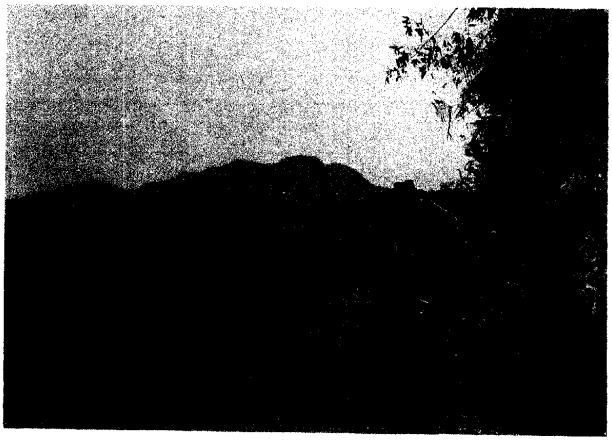

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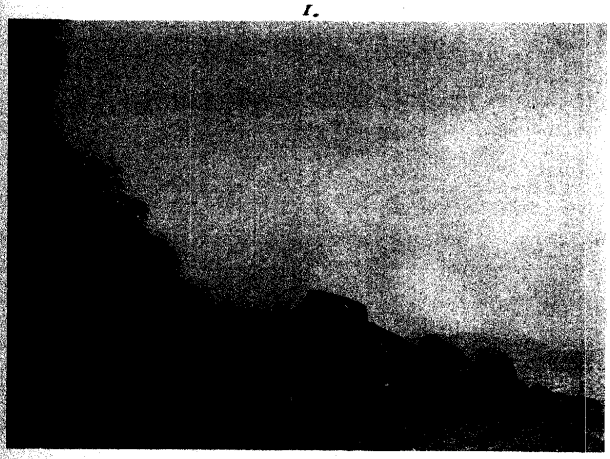

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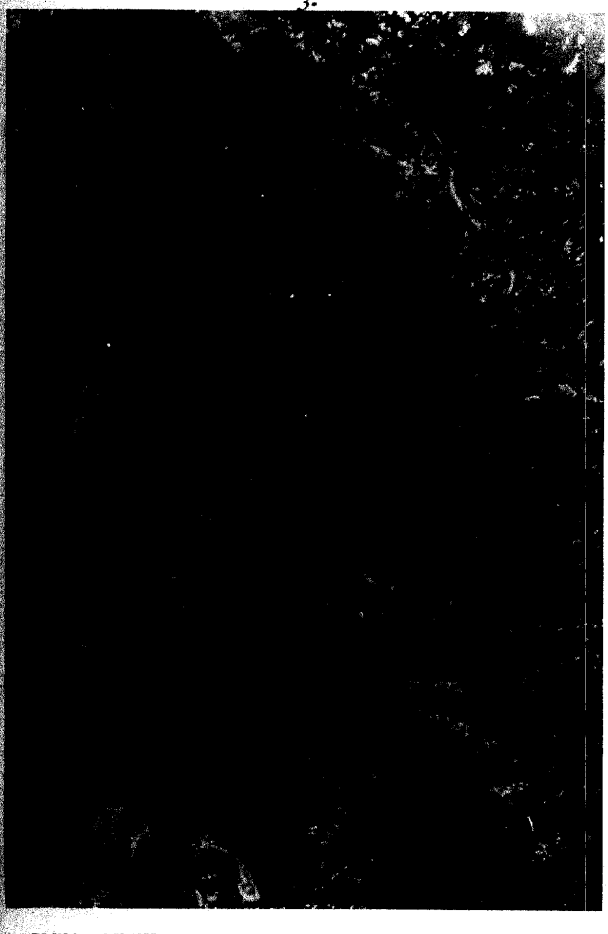

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EBINA and HANZAWA Photo.

PLATE XIX (II)

Fig. 1. A thin section of the nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima; showing *Nummulites amakusensis* YABE and HANZAWA, *Nummulites* sp., and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN. × 10.

Fig. 2. *Nummulites* sp. of *Nummulites lucasi* type; surface view; Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Fig. 3. A thin section of the nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima; showing *Nummulites amakusensis, Nummulites* sp. and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN. × 20.

Fig. 4. A thin section of the nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima; showing *Nummulites* sp. of *Nummulites lucasi* type, and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN. × 20.

Fig. 5. *Orthophragmina* (*Asterodiscus*) sp.; Hongô, Miyanokawachi, Amakusa-Shimo-shima; an approximately horizontal section, slightly excentric, showing polygonal arrangement of median chambers, and numerous pillars traversing lateral chambers. × 20.

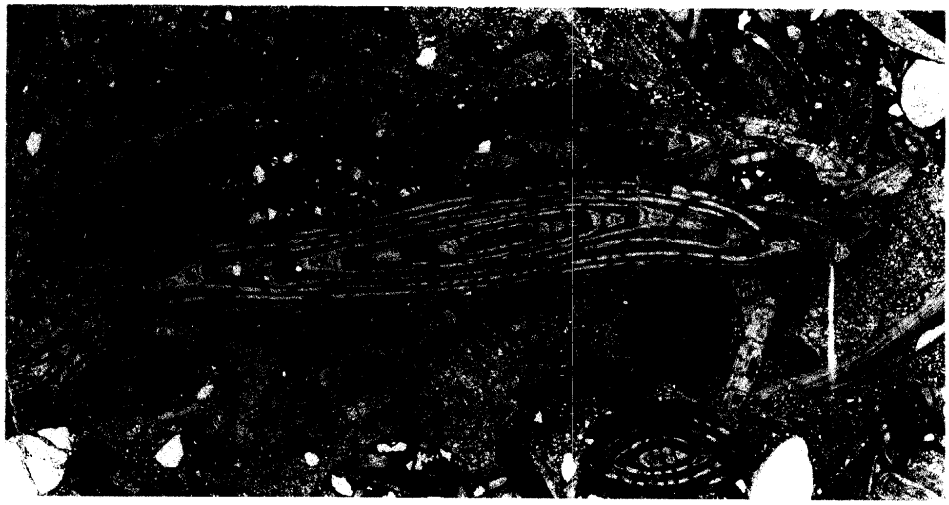
Fig. 6. Nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima; weathered surface. × 10.

Fig. 7. *Nummulites* sp. from Hongô, Miyanokawachi, Amakusa-Shimo-shima; a horizontal section through bilocular nucleoconch. × 20.

Fig. 8. *Nummulites* sp. of *Nummulites lucasi* type from Hongô, Miyanokawachi, Amakusa-Shimo-shima; an oblique tangential section, showing a cluster of narrow pillars at the center. × 20.

Fig. 9. *Nummulites subamakusensis* YABE and HANZAWA from Hongô, Miyanokawachi, Amakusa-Shimo-shima; surface view of an isolated specimen. × 10.

Figs. 10, 11. *Nummulites planulatus-elegans* LAM. from the Ypresian of Soison, France, in transverse section. Fig. 10, two megalospheric specimens (× 20); Fig. 11, a microspheric specimen. × 10.



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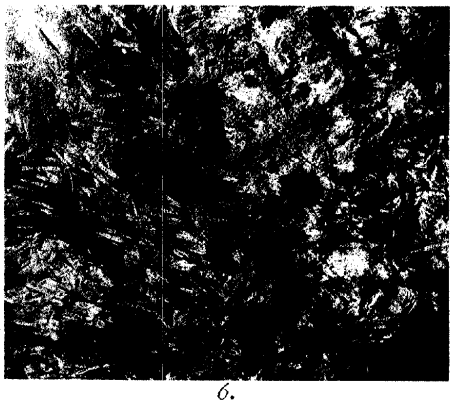

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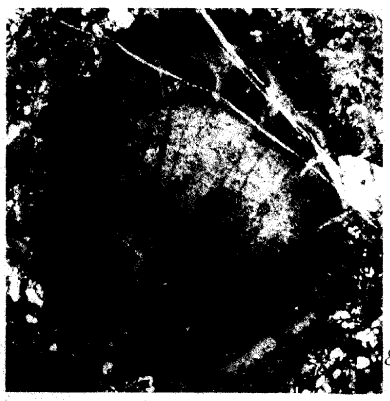

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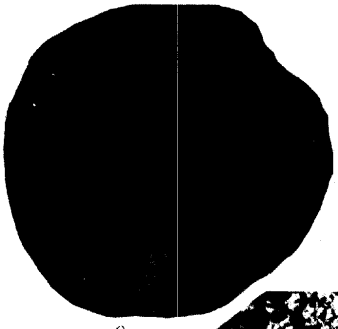

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EBINA and HANZAWA Photo.

PLATE XX (III)

Fig. 1. *Nummulites amakusensis* YABE and HANZAWA and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN and *Orthophragmina* (*Asterodiscus*) sp.: Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Fig. 2. *Nummulites amakusensis* YABE and HANZAWA (in horizontal section, but slightly excentric), *Nummulites* sp., and *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN: Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Fig. 3. *Nummulites amakusensis* YABE and HANZAWA; a horizontal section, almost sagittal: Taguizaki, Shishi-jima. × 10.

Fig. 4. *Nummulites subamakusensis* YABE and HANZAWA, an oblique section through the nucleoconch, and *Nummulites amakusensis*, a tangential section. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Fig. 5. *Nummulites subamakusensis* YABE and HANZAWA, a sagittal section. × 20.

Fig. 6. *Nummulites* sp. of *Nummulites subatacicus* type, surface view of an isolated specimen: Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Figs. 7, 8. *Nummulites planulatus* LAM. from the Ypresian of Cuise, France; a sagittal (7) and a transverse (8) section. × 10.

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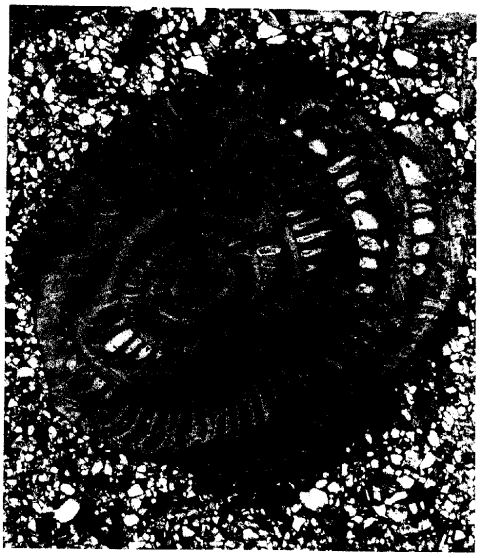

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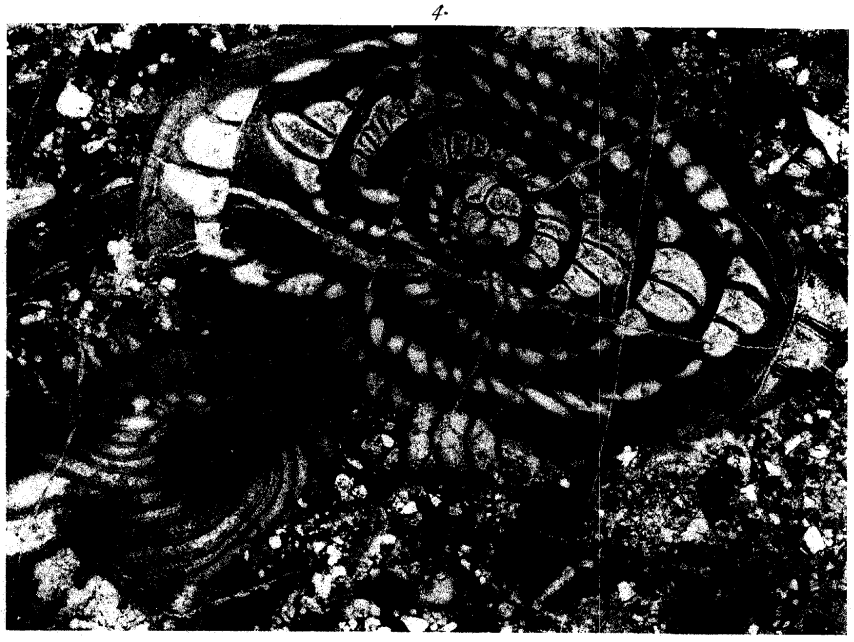

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EBINA and HANZAWA Photo.

PLATE XXI (IV)

Fig. 1. *Nummulites* sp. of *Nummulites guettardi* type; an oblique section: Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

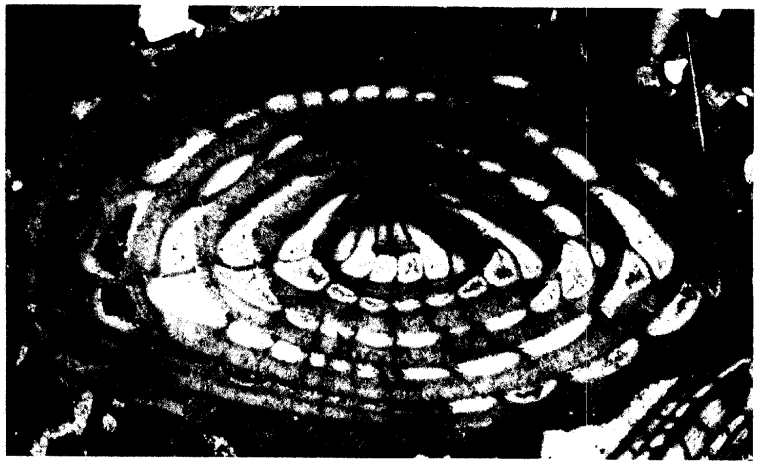
Fig. 2. *Nummulites* sp. and *Orthophragmina* (*Asterodiscus*) sp., both in transverse section through nucleoconch. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Figs. 3, 4. *Nummulites subamakusensis* YABE and HANZAWA, in transverse section through nucleoconch. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Figs. 5, 6. *Nummulites subamakusensis* YABE and HANZAWA, in transverse section through nucleoconch. Taguizaki, Shishi-jima (5) and Hongô (6). × 20.

Fig. 7. *Nummulites subamakusensis* YABE and HANZAWA and *Nummulites* sp., both in sagittal section. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Fig. 8. *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN (lower figure) and *Orthophragmina* (*Asterodiscus*) sp. (upper one); both in horizontal section, excentric. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.



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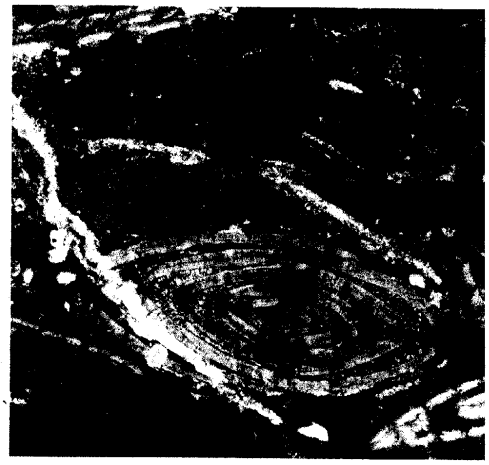

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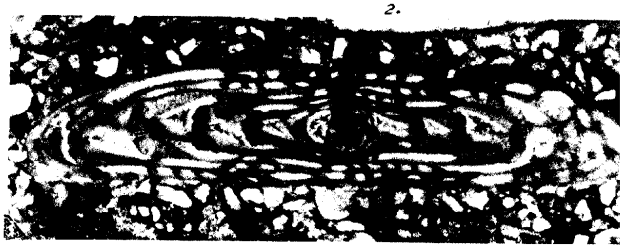

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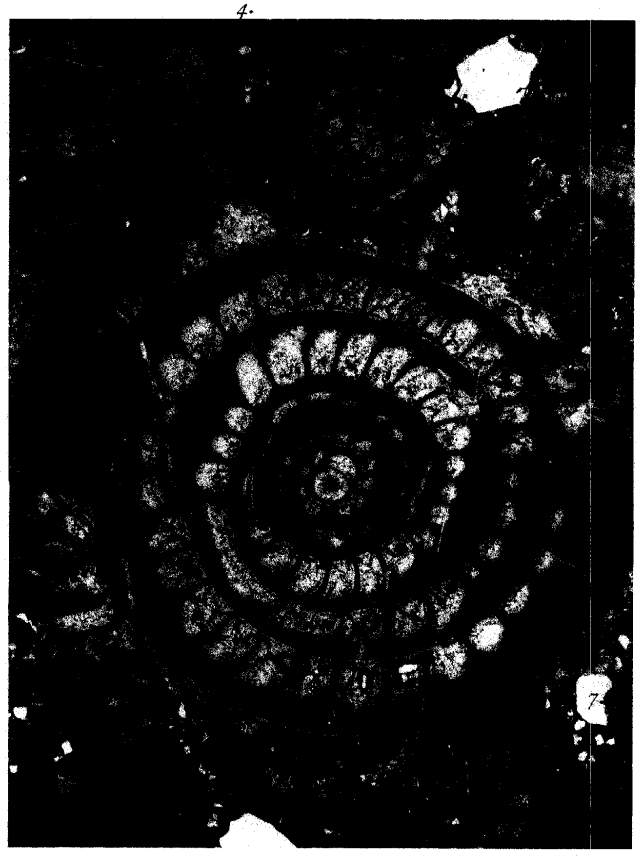

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PLATE XXII (V)

Fig. 1. A thin section of nummulitic limestone from Hongô, Miyanokawachi, Amakusa-Shimo-shima; *Nummulites* sp. (near the center) and *Orthophragmina* (*Asterodiscus*) sp. (in a transverse section through nucleoconch). × 20.

Figs. 2–4. *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN, a horizontal (2), oblique (3), and transverse section (4), all through nucleoconch. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Fig. 5. *Orthophragmina* (*Discocyclina*) aff. *pratti* MICHELIN (left) and *Orthophragmina* (*Asterodiscus*) sp. (right): Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Figs. 6, 7. *Orthophragmina* (*Asterodiscus*) sp., from Hongô, Miyanokawachi, Amakusa-Shimo-shima. Fig. 6, a transverse section through nucleoconch. × 20. Fig. 7, surface view of the central part of an isolated specimen. × 10.

Fig. 8. *Nummulites* sp. (type 3); surface view of an isolated specimen. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Figs. 9–11. *Nummulites* sp.; 9 and 10, in oblique section, and 11, in horizontal section, very excentric. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 20.

Fig. 12. *Nummulites* sp. of *Nummulites guettardi* type; surface view of an isolated specimen. Hongô, Miyanokawachi, Amakusa-Shimo-shima. × 10.

Figs. 13, 14. *Orthophragmina* (*Discocyclina*) *pratti* MICHELIN from the Eocene of Kressenburg, Bavaria; in transverse (13) and horizontal section (14). × 8.


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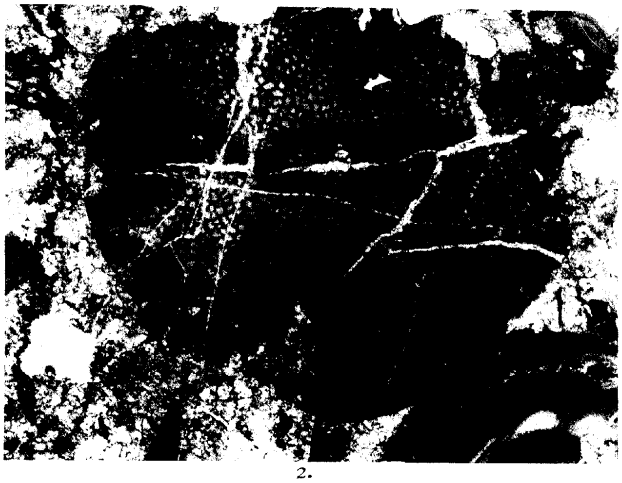
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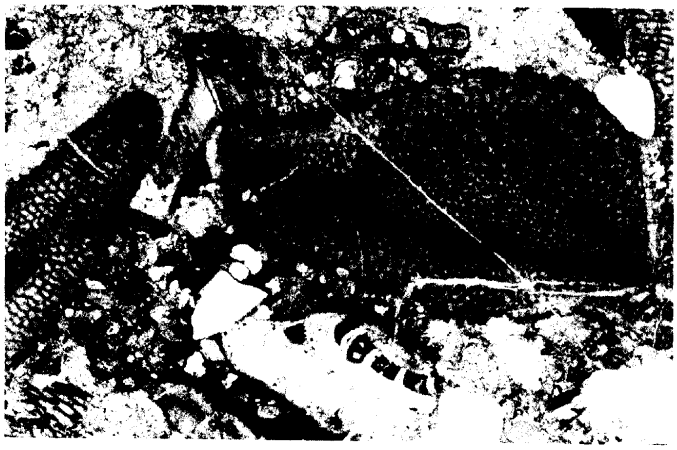
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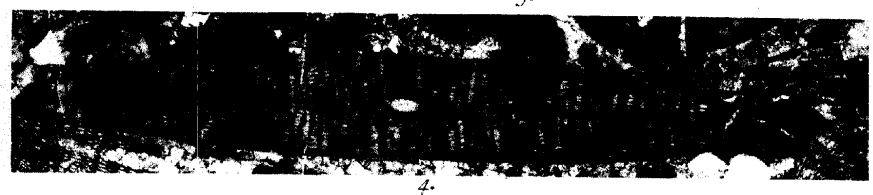
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